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THE PRICE-DIVIDEND RELATIONSHIP IN INFLATIONARY AND DEFLATIONARY REGIMES

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THE PRICE-DIVIDEND RELATIONSHIP IN INFLATIONARY AND DEFLATIONARY REGIMES

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Abstract.

This paper suggests that dividends do not reflect permanent earnings of corporations in periods of high inflation and deflation, and therefore the price-dividend relationship, as predicted by Gordon's dividend-price model, breaks down. Using data for the US and the UK over the period from 1871 to 2002, nonlinear estimates support the prediction of the model.

JEL classification: C32, C51, C52, G12, E44

Keywords: Regime-switching, nonlinearity, price-dividend relationship, inflation and deflation.

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1. Introduction

The Gordon (1962) growth model suggests that share prices have a linear relationship to dividends provided that the required returns to equity and the expected growth in dividends are constant. An underlying assumption of the model is that dividends reflect the permanent earnings capacity of the firm and therefore that changes in dividends should lead to proportional changes in share prices. However, several financial economists have questioned the validity of this property. Ackert and Hunter (1999, 2001) show theoretically and empirically that the dividend-share price relationship is nonlinear because managers place upper and lower bounds on dividends. Similarly, the literature has consistently found that managers exhibit a bias against lowering nominal dividends because it can have direct consequences for their share prices (see for example DeAngelo *et al*, 1992, Michaely *et al*, 1995).

This paper argues that the share price-dividend relationship becomes less clear-cut in deflationary and high inflationary environments. In periods of deflation managers are reluctant to lower nominal dividends by the rate of deflation even if they consider the real earnings capacity of the firm to be unaltered because lowering nominal dividends may lead to adverse reaction by the market. Consequently the price-dividend relationship becomes blurred. The price-dividend relationship also becomes blurred in periods of high inflation because shareholders and managers are unlikely to hold the same expectations about inflation due to the signal extraction problem that has been stressed by Lucas (1973). As argued by Friedman (1977), the variability of inflation is a positive function of the level of inflation. Hence, it becomes more difficult to predict inflation at high rates, and the divergence in the inflationary expectations of shareholders and managers is likely to widen to such an extent that Gordon's model breaks down.

Using data over the period from 1871 to 2002 for the US and the UK, the price-dividend relationship and its dependence on the rate of price change is estimated in a three-regime setting using a nonlinear estimation technique and the results are compared to OLS estimates of the Gordon growth model.

2. The price-dividend relationship and inflationary regimes

The fundamental value of a share is the discounted value of dividends provided that the transversality condition of the absence of speculative bubbles is satisfied. Allowing the growth in dividends and the required returns to shares to be constant, the discount model collapses to the Gordon growth model:

$$P_t = \int_{t=0}^{T} e^{-\rho t} D_t dt = \frac{D_t}{\rho - g}, \tag{1}$$

where P is the share price, D is dividends per share, ρ is the required returns to shares, and g is the growth rate in dividends. Since the Gordon model is derived under the assumption of a constant discount factor and growth rate in dividends, it collapses to the following log-linear relationship:

$$\log P_t = \log D_t + C,$$

where C is a constant.

However, the Gordon growth model breaks down in periods when dividends do not reflect the permanent earnings capacity of the company. This is particularly true in periods of deflation and high inflation. Deflationary periods have been experienced in the US and the UK over the periods from about 1870 to 1900, and from 1921 to 1922, and from 1927 to 1933. Some OECD countries have also experienced deflation more recently. High inflation has been experienced in the post WWI and WWII periods and in the 1970s in all OECD countries.

The consequence of deflation is that the price-dividend relationship breaks down because firms need to increase the real value of dividends to keep the nominal value of dividends unaltered. This is particularly true in periods of strong deflation. Empirical studies find severe share market reactions to *nominal* dividend reductions (see, for example DeAngelo *et al*, 1992, Michaely *et al*, 1995). Hence, to prevent a negative share market reaction firms seek to keep nominal dividends unaltered and the resulting increase in the real value of dividends is likely to overstate the change in the permanent earnings of the company. Rational investors will of course be aware of this problem, but the management wants to avoid a negative reaction in the share market from uninformed investors.

In periods of high inflation the price-dividend relationship is also likely to break down because of information extraction problems. In his Nobel lecture, Friedman (1977) argues that there is a positive relationship between inflation and the dispersion of relative price change, and several empirical studies have found evidence for Friedman's hypothesis (see Silver and Ioannidis, 2001, for references). For the price-dividend relationship, this implies that in periods of high inflation managers and shareholders are likely to hold different expectations about the prices of the company's products. The shareholder has information about the general price level but little information about the product prices that are relevant for the company's earnings potential. This leads to the famous information extraction problem suggested by Lucas (1973). It follows that dividends will convey less information about the earnings potential of the firm in periods of high

inflation.

3. Empirical estimates

Both a simple log-linear model and a more complete nonlinear model are estimated in this section using annual data for the US and the UK over the period 1871-2002.[2] The following log-linear model is estimated:

$$\Delta p_t = \lambda_0 + \lambda_1 \Delta d_t + \lambda_2 (p_{t-1} - d_{t-1}) + v_t \,, \tag{2}$$

where v_t is a stochastic error-term and lowercase letters are logs of uppercase letters. This model is the Gordon growth model augmented with an error-correction term, ($p_{t\text{-}1} - d_{t\text{-}1}$), to allow for the possibility that dividends do not entirely reflect permanent earnings, as discussed in detail below. The variables p_t and d_t are measured in nominal terms.[3]

In the nonlinear estimates the price-dividend relationship is subdivided into three inflationary regimes defined as $M1$, $M2$, and $M3$. In regime $M1$ the rate of price change is below the boundary τ^L; in regime $M2$ the rate of change in prices is within the boundaries of τ^L and τ^U; and in regime $M3$ the rate of change in prices is above the boundary of τ^U. For convenience, below τ^L is referred to as deflationary, between τ^L and τ^U is referred to as moderately inflationary and above τ^U as high inflationary regimes, respectively, although the boundaries are endogenously determined.

The following nonlinear model is estimated:

$$\Delta p_t = \theta_{1t} M_{1t} + \theta_{2t} M_{2t} + (1 - \theta_{1t} - \theta_{2t}) M_{3t} + \varepsilon_t \tag{3}$$

$$M_{1t} = \beta_{10} + \beta_{11} \Delta d_t + \beta_{12} (p_{t-1} - d_{t-1}) \tag{4}$$

$$M_{2t} = \beta_{20} + \beta_{21} \Delta d_t + \beta_{22} (p_{t-1} - d_{t-1}) \tag{5}$$

$$M_{3t} = \beta_{30} + \beta_{31} \Delta d_t + \beta_{32} (p_{t-1} - d_{t-1}) \tag{6}$$

$$\theta_{1t} = pr\{\pi_t < \tau^L\} = 1 - [1 + \exp\{-\gamma_1 (\pi_t - \tau^L)\}]^{-1} \tag{7}$$

$$\theta_{2t} = pr\{\tau^L < \pi_t < \tau^U\} = 1 - [1 + \exp\{-\gamma_2 (\pi_t - \tau^L)(\pi_t - \tau^U)\}]^{-1} \,, \tag{8}$$

[2] Dividends and share prices for the UK are from Grossman (2002) from 1871 to 1913 and from Barclays Capital (2001) from 1914 to 2000. The US share market index and dividends are from Global Financial data over the period from 1871 to 1999. Consumer prices are from Mitchell (1975, 1983). All data are updated using data from DataStream and IMF, *International Financial Statistics*.

[3] ADF tests for the 1871-2002 period (see the notes of Table 1), show evidence of cointegration for the UK but not the US and that Δp_t, Δd_t and π_t are stationary at conventional significance levels. Akaike's Information Criterion is used for selection of the lag length of the ADF tests.

where π_t is the rate of change in prices approximated by the log first-differences in consumer prices, τ^U is the upper bound of inflation, τ^L is the lower bound of inflation/deflation, and ε_t is a disturbance term. In Equation (3) the proportional change in share prices, Δp_t, is a weighted average of M_{1t}, M_{2t} and M_{3t}. M_{1t}, M_{2t} and M_{3t} are in turn linear functions of the dividend growth rate, Δd_t, augmented by the error correction terms. The error correction terms are included in the models to allow for the possibility of a long-run relationship between p_t and d_t.

Equation (7) determines the regime weight, θ_{1t}, as the probability that π_t is below the lower regime boundary of τ^L, whereas Equation (8) determines the regime weight, θ_{2t}, as the probability that π_t is within the regime boundaries at τ^L and τ^U.[4] The term (1- θ_{1t} - θ_{2t}) denotes the probability that π_t is higher than the upper regime boundary at τ^U. The smoothness parameters γ_1, $\gamma_2 > 0$ determine the smoothness of the three transition regimes. The model belongs to the class of multiple-regime Smooth Transition Auto-Regressive (MRSTAR) models in which inflation drives the transition amongst regimes.[5] The model collapses to a linear model if $\beta_{1i}= \beta_{2i} = \beta_{3i}$, for i=0,..,2. The model generalizes the quadratic logistic STAR model where only two regimes are allowed for (see e.g. van Dijk *et al*, 2002). Following Granger and Teräsvirta (1993), γ_1 and γ_2 are made dimension-free by dividing them by the standard deviation and the variance of π_t, respectively.

The error-correction terms are included in the estimates to allow share prices to converge to their long-run equilibrium. The price-dividend ratio may deviate from its long-run equilibrium due to changes in expected growth in dividends (Barsky and De Long, 1993) and because the risk premium is counter-cyclical (Campbell and Cochrane, 1999). However, the price-dividend ratio will gravitate towards its constant mean in the long run. It is particularly important to allow for error-correction in the high inflation and the deflationary regimes because the price-dividend relationship is likely to break down in these regimes as argued above. In the low inflation regime, however, dividends are more likely to reflect the permanent earnings capacity of the firm, which makes it less important to allow for an error-correction mechanism in this case. Note that while the model allows share prices and dividends to be cointegrated in different regimes, cointegration need not prevail over the whole estimation period.

The results of estimating Equation (2) are shown in columns (i) and (ii) of Table 1. The standard errors for the UK are based on White's heteroscedasticity consistent covariance matrix because the residuals exhibited heteroscedasticity. The estimated coefficient of dividends is significantly different from zero at the 5% significance level for the US but not for the UK.

[4] Equation (8) has the properties that 1) θ_{2t} becomes constant as $\gamma_2 \to 0$; and 2) as $\gamma_2 \to \infty$, θ_{2t}=0 if $\pi_t < \tau^L$ or $\pi_t > \tau^U$ and θ_{2t}=1 if $\tau^L < \pi_t < \tau^U$ (Jansen and Teräsvirta, 1996).

Conversely, the estimated coefficient of the error-correction term is significantly negative for the UK but not the US. Overall, the estimates suggest that there is some relationship between share prices and dividends, but that the relationship is not strong.

The results of estimating the three-regime nonlinear models are presented in columns (iii) and (iv) of Table 1. These are preferred to the log-linear ones based on the Akaike Information Criterion (AIC). The ratio of error variances, s^2_{NL}/s^2_L, is less than one, which gives further support to the suggestion that the nonlinear models are preferred to the log-linear models. Finally, F-tests for log-linearity in Table 1 reject the null hypothesis of log-linearity. Note that the estimated standard errors of γ_1 and γ_2 are relatively high. This should not be interpreted as evidence of weak nonlinearity, however, as pointed out by Teräsvirta (1994) and van Dijk *et al* (2002). Accurate estimation of γ_1 and γ_2 is difficult because it requires many observations in the immediate neighbourhood of the thresholds. Furthermore, large changes in γ_1 and γ_2 have only small effects on the shape of the transition function, which implies that estimates of γ_1 and γ_2 need not be precise (van Dijk *et al*, 2002).

The estimated lower price change regime boundaries are –0.1% for the US and –1.2% for the UK. These estimates are both very close to zero, which suggests that a shift from inflation to deflation changes the price-dividend relationship, as predicted by the theory in the previous section. The upper price change regime boundary is estimated to be 3.2% for the US and 6.4% for the UK. These boundaries are again consistent with the hypothesis of this paper that information asymmetries are likely to increase above a certain inflation threshold. The upper bound is higher for the UK than the US, which may, to some extent, reflect that the average level of inflation for the UK is almost 1-percentage point higher than for the US. A suggested by Lucas (1973), agents are likely to be more susceptible to the consequences of inflationary shocks as the rate of inflation grows higher.

The estimates indicate a substantial dividend effect within the bounds (M_2 regime) and that the estimated coefficients of dividends doubles on average in comparison with the simple log-linear models (Equation (2)). Furthermore, the estimated coefficient of dividends for the US is not significantly different from one at the 1-percentage level (F-test =6.313; p-value=0.013), as predicted by the Gordon model. That the estimated coefficients of dividends are below one is likely to reflect an errors-in-variables bias. The estimated coefficient of dividends is only one to the extent that dividends reflect the permanent earnings potential of the firm under the null hypothesis that the Gordon growth model is true.

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[5] See van Dijk *et al* (2002) for more details about multiple STAR models.

The dividend effects are insignificant at the 5% level in the deflationary (M_1) and high inflation (M_3) regimes for both countries. The positive dividend effect, as predicted by the Gordon model, disappears entirely in the high inflation regime. In other words, dividends do not convey any information about permanent earnings, as perceived by shareholders, in high inflation periods. There is, however, a strong error-correction effect in the high inflation regime, which suggests that share prices will eventually converge to the long-run equilibrium defined by the Gordon growth model, but that short-term changes in dividends do not give reliable signals to share holders about the earnings capacity of the firm. This is exactly what the signal extraction model of Lucas, as discussed in the previous section, predicts.

4. Conclusions

This paper argues that dividends are unlikely to represent the expected earnings capacity of a company in periods of deflation and high inflation. Using long data for the US and the UK, the estimates support the model and show that a significant price-dividend relationship could only be maintained at moderate levels of inflation.

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Table 1. Estimates of linear and non-linear Δp_t models, 1871-2002.

	(i) US linear	(ii) UK linear	(iii) US non-linear	(iv) UK non-linear
M_{1t} regime:				
constant	0.033 (0.016)	0.039 (0.013)	0.025 (0.052)	0.015 (0.023)
Δd_t	0.269 (0.116)	0.090 (0.082)	0.454 (0.243)	0.111 (0.246)
$(p_{t-1} - d_{t-1})$	-0.096 (0.054)	-0.250 (0.086)	-0.206 (0.129)	-0.059 (0.151)
M_{2t} regime:				
constant			0.034 (0.016)	0.032 (0.015)
Δd_t			0.631 (0.146)	0.294 (0.118)
$(p_{t-1} - d_{t-1})$			-0.033 (0.073)	-0.087 (0.093)
M_{3t} regime:				
constant			0.014 (0.016)	0.020 (0.015)
Δd_t			-0.416 (0.241)	-0.002 (0.093)
$(p_{t-1} - d_{t-1})$			-0.164 (0.067)	-0.495 (0.147)
τ^L			-0.133 (0.239)	-1.202 (1.164)
τ^U			3.196 (0.452)	6.356 (1.385)
γ_1			123.0 (206.090)	15.019 (27.028)
γ_2			35.34 (41.526)	4.416 (2.774)
s_L	0.178	0.157		
s_{NL}			0.173	0.151
s^2_{NL}/ s^2_L			0.944	0.925
AIC	-0.587	-0.839	-0.601	-0.880
Durbin-Watson	1.970	1.900	1.941	1.911
AR(2)	2.985 [0.054]	0.517 [0.597]	3.436 [0.035]	0.507 [0.603]
HET	0.806 [0.523]	2.939 [0.023]	1.477 [0.110]	1.887 [0.090]
ARCH(1)	1.374 [0.243]	28.115 [0.000]	1.429 [0.234]	4.829 [0.030]
Ho: $\beta_{1i}= \beta_{2i} =\beta_{3i}$			2.907 [0.016]	4.219 [0.001]

Notes: Standard errors are given in parentheses. For the UK, White's heteroscedasticity consistent standard errors are used. s_L (s_{NL}) is the standard error of the linear (non-linear) regression. AR(2): F-test for up to 2nd order serial correlation. ARCH(1): 1st order Autoregressive Conditional Heteroscedasticity F-test. HET: F-test for Heteroscedasticity. Numbers in square brackets are the p-values of the test statistics. AIC: Akaike Information Criterion. The $\beta_{1i}= \beta_{2i} =\beta_{3i}$ (for i=0,..,2) test is an F-test.

ADF tests on US data: p_t: -1.706; d_t: 1.220; $(p_{t-1} - d_{t-1})$: -2.390; Δp_t: -9.355**; Δd_t: -6.906**; π_t: -3.117*.

ADF tests on UK data: p_t: 1.924; d_t: 1.559; $(p_{t-1} - d_{t-1})$: -5.708**; Δp_t: -8.261**; Δd_t: -5.674**; π_t: -4.790**.

** Indicates rejection of the unit root hypothesis at 1 percent. * Indicates rejection at 5 percent. Lag lengths for the ADF tests are chosen by the AIC.